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RECOMMENDED PRACTICES FOR ENCAPSULATING HIGH VOLTAGE ASSEMBLIES

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E. W. TANKISLEY

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GODDARD SPACE FLIGHT CENTER
GREENBELT, MARYLAND

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E. W. Tankisley

ENGINEERING SERVICES DIVISION

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RECOMMENDED PRACTICES

FOR ENCAPSULATING

HIGH VOLTAGE ASSEMBLIES

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ABSTRACT

The purpose of this document is to give general instruction for preparation and encapsulation of high voltage assemblies. Related problems in encapsulating are brought out in these instructions.

A test sampling of four frequently used encapsulating compounds are shown in table form. The purpose of this table is to give a general idea of the working time available and the size of the container required for mixing and de-aerating.

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INTRODUCTION

High voltage assemblies are encapsulated primarily to prevent corona and arcing. Encapsulants also add structural reinforcement, close off components from the environment, and help prevent mechanical damage during handling.

Common causes of corona and arcing in encapsulated assemblies are trapped air around the components and air bubbles in the encapsulating material. These defects can be minimized by vacuum de-aerating the mixed encapsulating material and by pouring the material while under vacuum. An additional defect that can cause voltage breakdown is lack of adhesion of the encapsulating material to the assembly. Adequate adhesion can be insured by proper cleaning or primary practices.

PROCEDURE

The following procedure describes practices employed by the Plastics Section, Engineering Services Division, for eliminating voids and air bubbles in the encapsulating meterial.

1. <u>Cleanliness and Care in Handling</u>

    a. Provide clean work area and clean equipment.

    b. Inspect encapsulating materials to insure freedom from foreign matter.

    c. Check expiration date on dated materials. Outdated materials shall not be used.

    d. Cover electronic assembly when not in actual use. Handle assembly with care.

    e. Visually inspect assembly for broken solder connections and broken leads.

2. <u>Surface Preparation</u>

a. Clean the assembly with 200-proof ethyl alcohol using clean stiff brush, or clean air stream. When cleaning with a liquid, let drain and air dry.

Ultrasonic cleaning, sandblasting, or chemical etching should be used only with approval of Quality Assurance.

b. If a silicone rubber polymer is used as the encapsulation material, all surfaces making contact with silicone shall be primed with manufacturers specified silicone primer. If the assembly is of an open design, it shall be dip-coated in primer. If it is a self-contained assembly, the primer shall be poured into the assembly and then poured off. Primer on surfaces where not wanted should be washed off immediately with 200-proof ethyl alcohol. Most silicone rubber primers should air-dry one hour at ambient temperature. After the primer has dried, inspect assembly to make certain all component parts are primed, and if self-contained, all walls of the container primed; if not, prime again.
NOTE: Never reuse primer!

c. Inspect assembly container for leaks around leads, connectors, mounting holes and possible separations in container joints. Seal leaks with a material that will not contaminate or inhibit curing of encapsulating material, will hold up under heat of oven curing, and will be easily removed. (Example: Dow Corning R.T.V. 3116). (See Figure 1.)

d. Extra height is needed in assembly container to allow for expansion of encapsulating material under vacuum. Materials for height extension are to have the same requirements as material in Step 2 (c). (See Figure 1.)

e. If assembly is to be placed in a mold, and mold removed after curing, a suitable release agent is applied. Materials for molds and release agents are to have the same requirements as material in Step 2 (c).

3. <u>Preparing Encapsulating Material</u>

a. Mixing container shall be clean, nonporous, as polyethylene or glass. Do not use paper cups. Mixing instrument shall be a clean stainless steel spatula, or clean glass rod. Size of mixing container shall allow for expansion of encapsulating material under vacuum. (See Table 1).

b. Using gram scales and allowing for weight of mixing container, weigh out required amount of resin, and add curing agent in proper ratio specified by manufacturer.

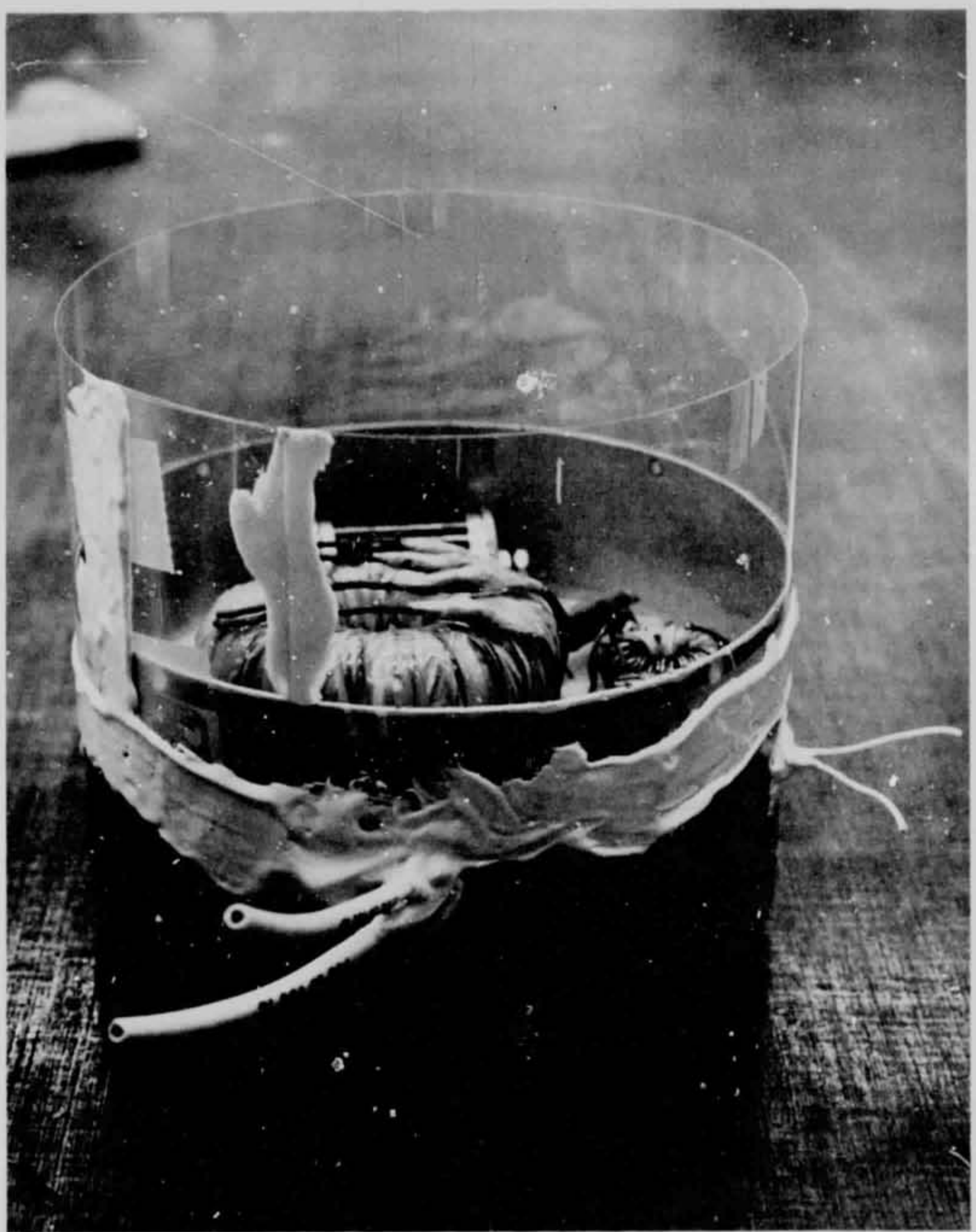

Figure 1. G75-01462 Self contained assembly with extension and sealing material.

Table 1
Materials — Time and Expansion Table

Material	Ratio of mix by weight	Time to de-aerate after mixing	Volume Expansion in Vacuum (times original volume)	Pot life Room temp.
Clear silicone rubber 93-500 resin 93-500 curing agent	Resin 10 parts Curing agent 1 part	10 minutes	4	1 hr. 20 min.
Polyurethane Solithane 113 resin C113-300 curing agent Resin and curing agent preheated separately to 52C	Resin 50 parts Curing agent 50 parts	7 minutes	2	6 hrs. 45 min.
Epoxy Epon 828 resin V-40 curing agent Resin and curing agent Preheated separately to 52C	Resin 50 parts Curing agent 50 parts	35 minutes	20	1 hr. 45 min.
Filled Epoxy Stycast 3050 resin Catalyst 9 curing agent	Resin 100 parts Curing agent 7 parts	6 minutes	5	35 min.

Note 1: Test samples consisted of 1 cubic inch of material, mixed for 2 minutes.

Note 2: Pot life is measured from the time mixing is complete until the material begins to gel.

Mix thoroughly, making certain that mixing instrument comes in contact with sides and bottom of mixing container, so no unmixed materials remain. When a filler material is used, it shall be added only after resin and curing agent have been thoroughly mixed. Filler material is added and mixed gradually and thoroughly with resin mix. Most polyurethane and some epoxy manufact ·er's specifications call for heating resin and curing agent in separate containers before mixing, and also preheating the electronic assemblies when possible. These steps lower the viscosity, providing easier mixing and removal of trapped air.

c. Notice should be taken of manufacturer's pot life of mixed material, as this could be a controlling factor for total time under vacuum.
NOTE: With most mixed encapsulating materials, the larger the volume, the shorter the pot life. (See Table 1).

d. Place encapsulating material in its mixing container under vacuum where visible (as a glass bell jar), and begin pumping. If mixed material is of highly frothing nature and threatens to spill over mixing container, it will be necessary to partially vent the vacuum chamber, and begin pumping again. It may be necessary to repeat this several times. With most materials, after frothing has stopped and the material has collapsed, a few more minutes of pumping will provide sufficient de-aeration. (See Table 1).

4. Pouring Encapsulating Material and Vacuum Removal of Trapped Air

a. When pouring encapsulating material by hand into assembly, pour in a manner as to keep air bubbles to a minimum.
Examples: Tip container on an angle and pour slowly down side of container (See Figure 2). When the assembly has no large openings, then mixed material is added by gravity feeding. Material is placed in a clean container with a tube attached that will fit an opening. Suspend container with tube above assembly and allow to gravity-feed slowly. A second vent hole is required for escaping displaced gases. (See Figure 3).

b. After mixed material has reached proper level in assembly, it is placed under vacuum and pumped. Again, it may be necessary to vent the vacuum system several times, due to frothing action. Pumping is continued until all trapped air is removed, or when pot life ends (whichever takes place first). (See Table 1).

c. Vacuum encapsulating is preferred for best results, when practical. When pouring under vacuum by mechanical means, the electronic assembly

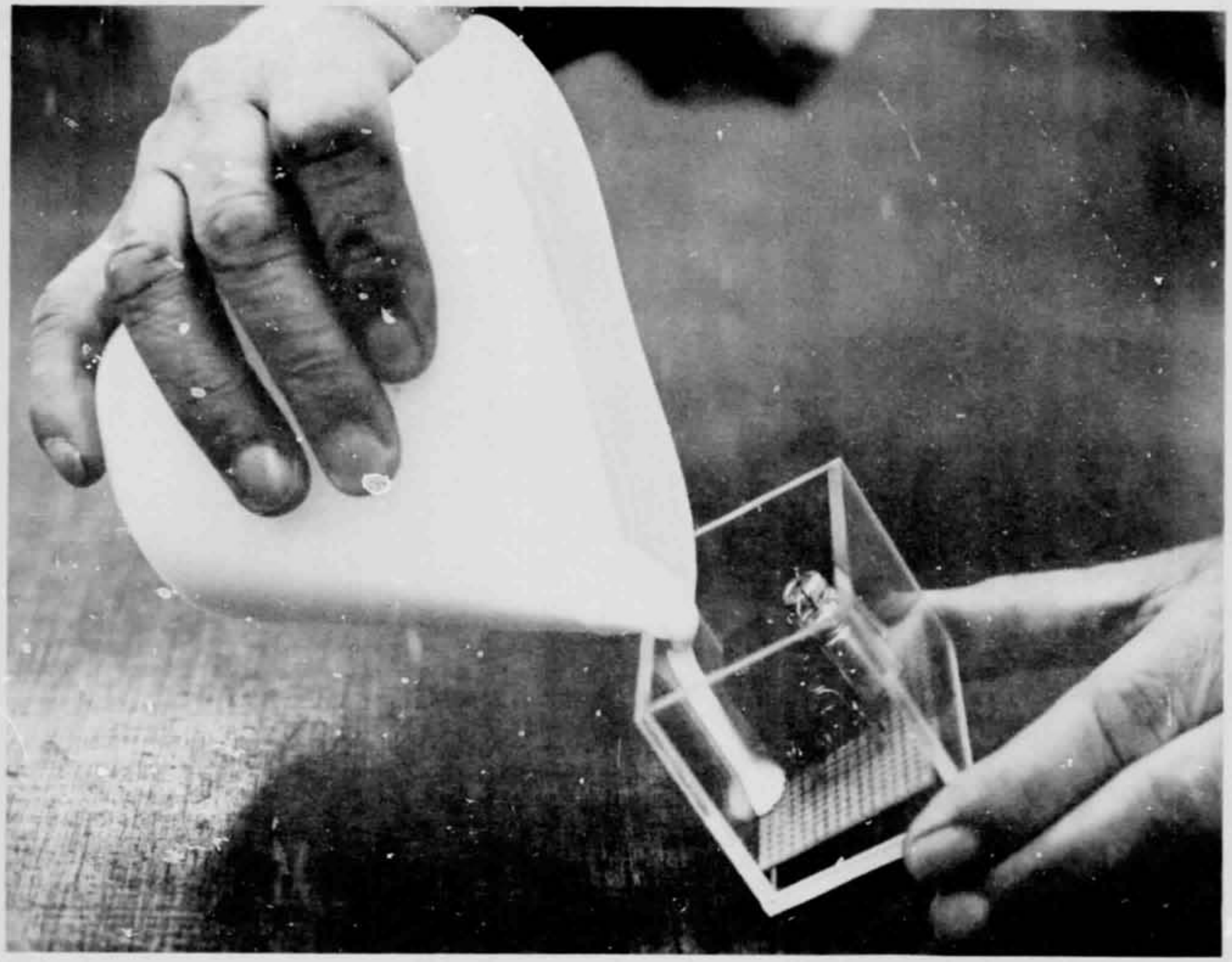

Figure 2. G75-01473 Hand pouring to prevent air entrapment.

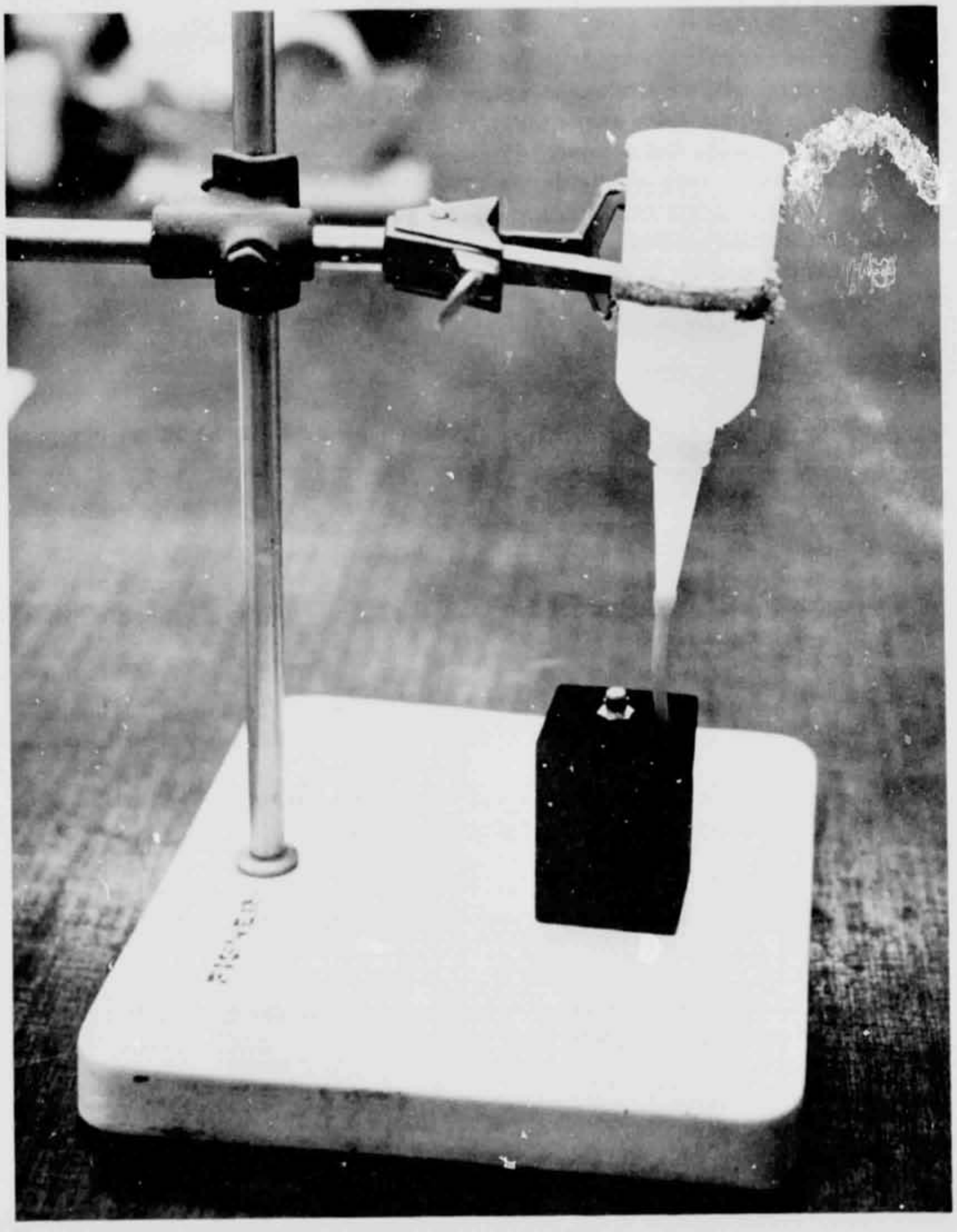

Figure 3. G75-01463 Gravity feeding of encapsulating material into self-contained assembly with small openings.

and mixed encapsulating material are both placed in the vacuum chamber. The electronic assembly is positioned so that, when mechanically pouring, material will not overshoot assembly. Before pouring, pump for 15 minutes to remove air from assembly. After air is removed from assembly, continue to pump, and commence to pour, slowly, into the assembly. Again, if a great amount of frothing is encountered, stop pouring; this alone may slow frothing action. If not, partial. vent the vacuum chamber. After encapsulating material has reached the proper level, pumping is continued until trapped air is removed, or when pot life ends (whichever takes place first). (See Figure 4).

5. Curing

a. Manufacturer's specified cure schedule shall be followed unless components cannot withstand the required temperature; then, a revised cure schedule is necessary.

Unless a room-temperature cure is specified, the assembly should be cured in a clean oven of the circulating type. Oven temperature shall be controlled to plus or minus 1 degree C. It should have a fail-safe override setting 5 degrees C above the preset level.

b. The oven shall be preheated to the specified temperature (or revised temperature), and the assembly placed in the oven in a level posit' n.

c. After the curing time, the unit shall be allowed to cool slow' ; oven to ambient temperature (annealing philosophy).

d. After removal from the oven, all sealing materials and added extensions are removed. The outside of unit shall be cleaned with 200-proof ethyl alcohol.

e. Keep the assembly in a clean condition by proper storage, as in a clean box or sealed polyethylene bag.

CONCLUSION

Many high voltage assemblies have been successfully encapsulated using this procedure. Modifications of the suggested practices are required in some instances; however, vacuum de-aeration of the encapsulating materials should be performed to insure a sound, bubble-free encapsulant.

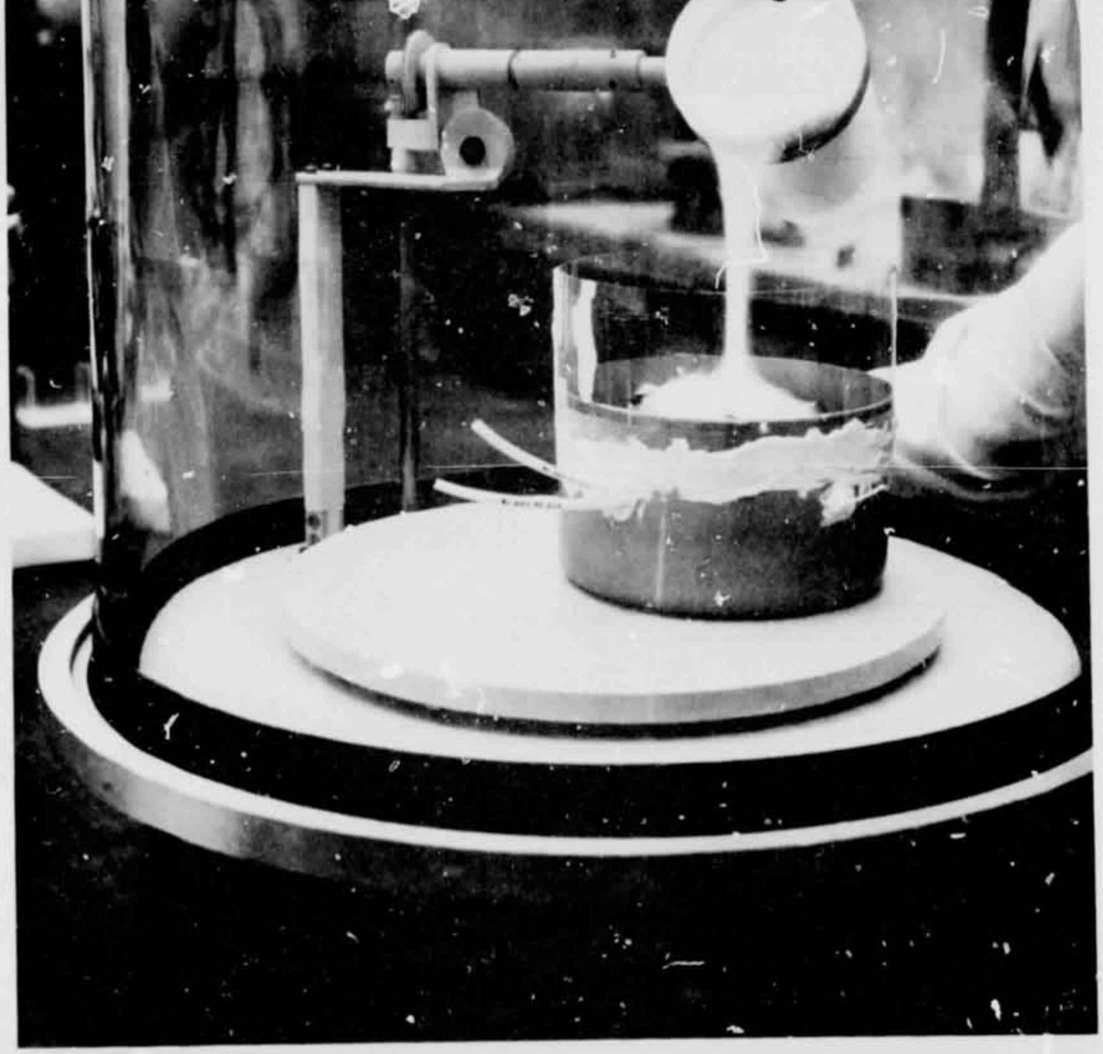

Figure 4. G75-01470 Pouring in vacuum by mechanical means.

When new or unfamiliar encapsulating materials are to be used, a trial run should be performed to check the behavior of the mixed material under vacuum, to determine the time required for de-aeration, and to establish the pot life.

ACKNOWLEDGEMENT

The author wishes to express his gratitude for the technical assistance of Mr. John L. Westrom, Space Power Technology Branch, Power Conversion and Control Section.

APPENDIX

The following is a list of materials and their manufacturers referred to in this document.

R. T. V. 3116 93-500 Silicone rubber 93-500 Curing Agent	Dow Corning Corp. Midland, Michigan
Solithane 113 resin C113-300 Curing agent	Thiokol Chemical Corp. Trenton, New Jersey
Epon 828 resin V-40 Curing agent	Miller-Stephenson Chemical Co. Danbury, Connecticut
Stycast 3050 resin Catalyst - 9	Emerson and Cuming, Inc. Canton, Massachusetts